

SHOULD LAPAROTOMY BE DONE FOR PENE-
TRATING GUNSHOT WOUNDS OF THE AB-
DOMEN INVOLVING THE VISCERA?¹

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MY chief object in presenting this subject for your consideration is a medico-legal one. A few years since the counsel for the defense in a famous murder trial asserted that the examination of the track of the ball by a probe in a penetrating gunshot wound of the abdomen, had turned the scale towards a fatal issue, cited many eminent authorities in support of this view, and urged the acquittal of his client of the crime of murder in the first degree. At present, the tendency seems rather towards the most active interference, to operations which in the most experienced hands cannot be denied to have a certain mortality *per se*, and which done promiscuously by those inexperienced in abdominal surgery will undoubtedly tend to render death more certain.

Laparotomy for these injuries has been guardedly endorsed by the American Medical Association, in a most emphatic manner by the New York State Medical Association at its last meeting, and by the Philadelphia Academy of Surgery. Nevertheless, protests have appeared in the journals from

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time to time, and although I was the first surgeon to venture upon the operation in Philadelphia, yet I feel impelled to ask that you most carefully consider what I advance, and after due deliberation express an authoritative opinion which may serve as a precedent for appeal. I say an "authoritative opinion" because it cannot be questioned that this body forms the highest surgical tribunal of the country. Some expression, for or against this operation, I look upon as imperative both in the interests of justice—that the guilty may not escape under pretense of improper treatment on the part of the surgeon—and that the surgeon may without fear of censure to influence his judgment, decide for or against laparotomy, solely in the interests of his patient.

The questions that must be decided are: What are the tendencies of the injury, are they towards recovery or death? When death takes place, what are its causes? When recovery ensues, what conservative processes occur? How likely are these conservative processes to take place, and what favors or prevents them? How reliable are unaided natural methods compared with those art affords, and should they be imitated by the surgeon or avoided? Finally, what are the dangers inherent to the operation of laparotomy and what advantages does it offer?

A preliminary consideration of the results of the experiments of Wegner and Grawitz will explain many otherwise inexplicable clinical facts, and clearly indicate the causes of the complications specially dreaded after ball injuries or a laparotomy, and how these dangers can be averted.

The first observer ascertained that the healthy peritoneum could dispose of ordinary air, serum, bile and healthy urine—any solid particles in these fluids being encapsulated—without any peritonitis resulting. When, however, air and putrescible fluids were simultaneously introduced in greater amount than could be disposed of *within a short time*, decomposition did occur, its products were absorbed and septicæmia resulted. A notable exception was that "living defibrinated blood never decomposed under these circumstances," an observation which seems to prove the truth of my suggestion that the presence

of fibrin ferment and probably its absorption, is one of the dangers of peritoneal traumatisms.

Grawitz's experiments are singularly in accord with those of the earlier observer Wegner, especially those whereby he proves that even the presence of large numbers of the ordinary forms of micro-organisms produces no evil effects so long as the quantity of putrescible fluids does not exceed that amount which can be absorbed or safely encapsulated within a limited time. These experiments prove the truth of the assertions of certain ovariotomists, that operations involving the peritoneum, provided due precautions be taken, are safer than most of those daily performed, since many species of micro-organisms can be introduced with impunity into the peritoneal cavity, while even the specific pus-producing forms cannot initiate suppuration except under certain conditions which can usually be avoided. Thus both observers found that "large quantities of the ordinary forms of micro-organisms," certain amounts of cholera-bacilli, or even of faeces, mingled with a putrescible albuminous substance like spleen-pulp, produced no peritonitis in the *healthy* peritoneum, provided the amounts introduced did not exceed that which the peritoneum could absorb or encapsulate, in about one hour's time. When the power of absorption of the peritoneum was impaired, no peritonitis resulted, but septicaemia, if the micro-organisms present could induce decomposition of the albuminous fluids. In like manner small quantities of the pyogenic micro-organisms, unless the injected fluid was chemically irritating, *i. e.*, could cauterize the peritoneal surfaces—produced no harm, unless the amount somewhat exceeded 10 c. c. m.

Suppurative peritonitis, however, was produced by these micro-organisms.

"(a). When stagnant fluid was present, capable of nourishing the micro-organisms (salt solution, bouillon), the bacteria developing more rapidly than the peritoneum could absorb them.

"(b). When caustic solutions had prepared a field for the growth of the micro-organisms by destroying the surface of the peritoneum.

(c). Especially when a wound of the peritoneum was present—even the hypodermic puncture made in introducing the cultures may be the starting point of the peritonitis."¹

The bearing of these observations upon the subject we are now studying is manifest. Unless free drainage is afforded for all albuminous fluids, despite the exclusion of specific organisms, the presence of the ordinary innocent micrococci will initiate putrescent changes which will cause septicæmia (sapraæmia?), provided the effusions exceed a small amount and the absorbent powers of the peritoneum are impaired. It is in the highest degree probable that this normal absorbing power of the peritoneum will be impaired by the shock of a severe injury, a prolonged operation, or the effects of both combined, under which circumstances unless free drainage is afforded, the effused albuminous fluids become "stagnant," and if specific organisms be present, even in such small quantities as under other circumstances would be safe, suppurative peritonitis will occur, and with additional ease if a wounded surface be present. The lesson to be learnt from these observations is unmistakable and is confirmed by clinical experience, viz., that effacement of all wounded surfaces, *i. e.*, their coaptation by suture—and free drainage, even in the presence of dangerous numbers of pyogenic organisms, will avert disaster.

Practical application of the teachings of these experiments in explanation of the causation of the fatal results of gunshot wounds of the abdomen, and to the technique of laparotomy for the relief of such injuries, clearly indicates that all blood and serum must be primarily removed with the most scrupulous exactness; provision for free drainage for further effusions must be provided, unless there is a reasonable certainty that these will be poured out in such small amounts as to be innocuous; every wounded surface must be coaptated

¹P. 120-124 ANNALS of SURGERY, 1887, contain a résumé of these experiments, the original articles appearing in Statisticher und experimentell-pathologischer Beitrag zur Kenntniss der Peritonitis—Charité Annalen, XI. Jahrb., 770 and Langenbecks Archiv. f. klin. Chir., Bd. XX, I, p. 51. I am indebted to Dr. Curtis's article for my facts.

with all attainable accuracy by such sutures and suture-needles as will leave the smallest superficies of injured peritoneum; the drainage opening—if a tube be deemed necessary—must be most strictly guarded; that depression of the circulation present during shock¹—either of injury or operation—must be removed by appropriate remedies; the vascularity of the peritoneum must be kept as near the norm as possible, to enable its absorbing function on the one hand to prevent suppurative peritonitis by permitting no collection of stagnant fluids to provide pabulum for any pyogenic bacteria which may have gained access to the cavity; on the other hand, septicæmia² induced by decomposition of the same stagnant albuminous fluids by the mere bacteria of putrefaction.

Having ascertained what experimental research teaches, I shall now endeavor to answer in order the questions propounded, and first, "What are the tendencies of the disease, are they towards recovery or death?

Examination of the only statistics on a sufficiently large scale shows that a fraction under 8 % of recoveries follow after penetrating abdominal wounds; but of this number some doubtless sustained no visceral injuries, as I shall soon show is not uncommon; others, perhaps, there were, the walls of whose hollow viscera were penetrated obliquely; others again in whom the alimentary tract was wounded in those parts which possess an anatomical arrangement unfavorable to the extravasation of their contents.

Thus the walls of the stomach and duodenum are of such thickness that even when directly penetrated by a small ball there is but little chance of primary extravasation, while when their walls are traversed obliquely there is apparently no tend-

¹The experiments of Goltz demonstrate that the abdominal viscera, including the peritoneum, are intensely congested in shock, and during prolonged abdominal operations we are all well acquainted with the increased vascularity of this membrane; in such a condition the power of absorption is greatly impaired and probably entirely lost, hence my advice.

²Certainly some, if not all of the so-called septicæmias are really sapræmias, *i. e.*, a disease produced by the absorption of ptomaines. When Wegner's observations were made, the subject of ptomaines was in its infancy, hence the term septicæmia instead of sapræmia.

ency at all towards primary escape of the visceral contents. The effects of the rate of speed of the ball, the obliquity of its track, and the anatomical disposition of parts is well illustrated by a case upon which I performed the first laparotomy for gun-shot wound done in Philadelphia. The first visceral wound was of the anterior wall of the stomach, and was so small and valvular as to require some manipulation with a director to determine that it was a penetration and not a contusion, neither gas nor fluids escaping on firm pressure on the organ.

The wound of exit was, of course, larger, yet still was water- and air-tight, but contrary to all expectation, the wound of entrance in the duodenum—and it must be remembered that there is no material difference in thickness of the walls of the duodenum and stomach—was much larger and more ragged than that of exit from the stomach, and freely permitted the escape of the duodenal contents. The actual conditions observed in my own case teach that while a single oblique wound under peculiarly favorable circumstances *may* not give rise to primary faecal or perhaps even gaseous extravasation and cure result, yet multiple ball wounds of the gut must necessarily always *admit* of, and probably result in both primary and secondary effusion of the visceral contents, if life be sufficiently prolonged. A single oblique wound of the urinary bladder produced by a small ball may possibly behave in the same manner, but I think not, for anatomical and physiological reasons too manifest to require explanation. A wound of the gall-bladder would under any circumstances remain patent. In proof of my statement that the abdomen may be traversed by a ball without visceral injury, I need only refer to the four cases reported some years ago by our President and which I shall presently cite for another purpose. Vomiting of, and the passage of blood may result from simple contusion of the viscera; emphysema of the abdominal wall can readily occur without wound of the gut, while tympany in the hepatic region is often most fallacious as proof of a wounded intestine.

After penetrating abdominal wounds, as after every other

injury howsoever severe, there are conservative processes initiated, which occasionally succeed unaided by art, yet from an impartial consideration of the above facts, it appears that when visceral wounds undoubtedly exist, the *tendencies* of these injuries are invariably towards death, recoveries being so rare as to be regarded and reported as surgical curiosities.

The escape of the few is only the exception to the rule, which, instead of making against operation will, when the process of spontaneous recovery is carefully studied, serve as an additional incentive to laparotomy, since this study will show upon how slender a thread hangs the chance of recovery, and how readily this delicate filament may be strengthened almost to a cable by a skilfully performed operation.

What is the cause of death? Hemorrhage in itself is rarely fatal in any case where an opportunity is afforded for operation, but may occur to a dangerous extent; especially in the young or aged, and that too from vessels of a size to be rightly considered insignificant were they not situated in a closed cavity. A collection of blood amounting to only an ounce or two may be fraught with fatal consequences, either from the induction of *sapraemia* or because it furnishes pabulum for the development of the organisms productive of suppurative peritonitis.

Death, however, is due in nearly every case to septic peritonitis, caused by extravasated flatus, faeces, urine or bile—possibly also by fragments of soiled clothing, as in a case presently to be quoted. Of those attacked with peritonitis due to faecal extravasation, over 90% die within 48 hours. The explanation of some exceptional recoveries is, that the free abdominal wounds resulting from large balls have afforded such effectual drainage for the escaping faeces that they have not become diffused throughout the abdominal cavity, while any resulting inflammatory products have likewise readily escaped. I have also already shown that the peritoneum can safely dispose of a limited amount both of faeces and flatus.

When recovery ensues what conservative processes occur? The effused gas or fluids are absorbed without producing either serious local trouble or systemic infection, and a limited adhesive inflammation results, just sufficient to glue the injured

organ to the abdominal wall or a neighboring viscus. It is possible that a wounded liver, kidney or spleen may heal without adhesion of the wounded organ to the nearest peritoneal surface, but I am unacquainted with any observations bearing upon these points.

Doubtless in some cases adhesions do form, shutting off for a time amounts of poisonous material beyond the capacity of the peritoneum to absorb either in time to prevent suppurative peritonitis or with safety to the organism, but owing to the septic character of the inflammation, the adhesions break down and death results. Bearing this in mind, the apparent answer of statistics as to the actual frequency with which conservative processes occur is probably far below the actuality, but so far as the permanency of adhesions and the safe absorption of deleterious matters goes, roughly speaking, these processes are successful in 8% of the cases.¹ Among the rarest of events in those who recover is the safe evacuation by abscess of the abdominal walls of a small primary faecal extravasation which has become limited by healthy adhesive inflammation, and the same event happening as the consequence of a secondary extravasation taking place among preformed firm adhesions. Far more commonly these so-called faecal abscesses burst into the peritoneal cavity and rapidly cause death in cases which, for a time, bade fair to recover.

What favors or prevents these conservative processes? The absence or slight extent of flatulent, faecal, urinary or biliary extravasation;² the absence or slight amount of effused blood or serum, *i. e.*, stagnant albuminous fluids in the abdominal cavity; a favorable relation of the wounds with reference to the neighboring viscera or the abdominal wall providing for free drainage in the exceptional cases just mentioned; valvular wounds; above all, an aseptic condition of the peritoneal surface of the wounds and their immediate environment, since without this no reliable, limited adhesive inflammation can occur.

¹Granting the diagnosis always correct; but in some of these recoveries probably neither abdominal nor visceral penetration existed.

²See results of experiments already quoted for truth of these and following statements.

cur; and partial or complete arrest of intestinal paralysis, *i. e.*, rest—admitting of the most perfect permanent coaptation of wounded serous surfaces which is feasible; all favor the conservative processes, while the reverse prevents them. Just here it must not be practically overlooked, although the theoretical belief is held by us all, that ball wounds of the abdomen and hollow viscera differ pathologically in many essential particulars from punctured or incised wounds. In the former more or less death of tissue must follow, from which results of necessity an unhealthy inflammation which usually becomes generalized; plugging of the wound by the everted mucous membrane is very unlikely; and effectual coaptation of neighboring serous surfaces, either of the wound or contiguous parts, can rarely occur; in consequence of all these circumstances, natural repair is very rarely permanent. Again, the edges of an incised wound of the mesentery are unlikely to slough, while the track produced by a ball infallibly will, and the dead tissue not being evacuable by the gut, as in a wound of the intestine, will produce fatal results, as has been already reported.

What has been already said sufficiently answers—and that in the negative—the question relative to the reliability of nature's methods as compared with those of art, and the advisability of imitating them. Even the good to be effected by arrest or diminution of normal peristalsis after laparotomy is doubtful, for, having effectually closed all wounds, any adhesion of neighboring organs is unnecessary, and, as a possible source of future trouble, is to be avoided.¹

The only question now left to answer is, what are the dangers inherent to laparotomy and what advantages does it offer? Shock—due in these cases to prolonged irritation of the abdominal sympathetic—and the risk of rendering a peritonitis septic and diffused, when it might have remained local and simple, are the special dangers of the operation; but, as we have it in our power to prevent a generalized peritonitis from

¹ The danger of old or even recent peritoneal bands is too well known to need proof. This view will be productive of good by doing away with one of the chief indications for the enormous doses of opium too often administered in traumatic peritonitis (Parke's also).

being originated by our manipulations, and to render the inflammation necessarily resulting from the accident comparatively innocuous, shock is all we need dread.

The advantages of operation are manifold. Thus, we can either forestall septic peritonitis or reduce its dangers to a minimum; we can prevent sapræmia—a common cause of death, as I believe—due to the absorption of ptomaines, or perhaps fibrin-ferment; should peritonitis have set in, we can afford efficient drainage for the effusions which may in themselves be already poisonous, or, as we have shown, will assuredly become the chief source of danger; we can substitute for adhesions of doubtful permanency certain methods which secure the escape of the injured portions of gut into the lumen of the bowel; we can prevent the fatal results which must follow the casting off of a decomposing slough of a wounded portion of omentum or mesentery into the general peritoneal cavity; we can arrest hemorrhage, which from its amount will prove fatal, or from its decomposition will equally produce lethal results; we can restore the continuity of the gut, if it be nearly or completely severed, the former condition being not uncommon; we can avoid the risk of fæcal fistula, which, had it occurred in my patient, would soon have destroyed life by inanition; and we can remove a hopelessly damaged kidney or spleen, and repair a wounded pancreas or liver.

If then my facts and the deductions drawn from them be true, all ball-wounds of the abdomen involving the intestines, stomach, bile or urinary bladder, should be treated by suture or resection and suture, injured omentum should always be excised and the wounded serous surfaces carefully sutured, wounds of the liver and pancreas treated as I shall presently state, and a wounded spleen or kidney extirpated; provided certain contra-indications, yet to be pointed out, do not exist.

But, it has been urged, every symptom except the escape of fæces, flatus, urine or bile from the external wound, has been demonstrated to be fallacious as a proof of visceral implication, and that the abdomen has been traversed from side to side without any of its contents being wounded. Granted: but listen to the abstracts of the histories of four cases re-

ported by our president, and ask yourselves the question, "could these cases have done worse than die, and would not they all have had a fair chance of recovery had the ball, effused blood, cloth, etc., been removed, a careful toilet of the peritoneum made, and effectual drainage instituted?" By the light afforded both by the investigations I have quoted, and clinical experience, but one answer can be given, and that an affirmative one.

A round ball, after travelling beneath the skin for some distance, penetrated the abdomen at the linea alba, passed downward, backward and to the left, lodging near the iliac bone. No wound or contusion of the bowels could be discovered after death on the third day, but a piece of cloth, lymph and three pints of reddish serum were found in the abdominal cavity. A conoidal pistol-ball entered obliquely to the right of the umbilicus, tore the parietal peritoneum, and emerged five inches below and to the left of the umbilicus. After death on the third day, no visceral injury was found, but lymph and a large quantity of bloody serum. A soldier "was wounded by a ball from a shrapnel shell which passed through the cavity of the belly and lodged in the muscles of the back;" another "was wounded by a minie bullet, which passed obliquely through the wall, entered the cavity for several inches, and then escaped through the anterior wall of the belly." The autopsies of these cases, like those of the two former, showed "peritonitis and the presence of large quantities of acrid bloody serum in the abdominal cavity," a combination of all the conditions experimentally proven to be most fatal; *i. e.*, diminished power of absorption, acrid fluids, stagnating fluids and wounded peritoneal surfaces, needing no injury of bowel, bladder or other viscera to destroy life.

It therefore follows that even penetrating abdominal wounds without involvement of viscera, are better treated by exploratory section than by the expectant plan of treatment, provided the operation be done with due care. Moreover, in many instances unsuspected injuries of blood vessels, contusions of bowel, of omentum or of the viscera, which will later on slough, will often thus be detected and appropriate treatment instituted.

The import of the last few sentences renders it hardly necessary to state that I lay little stress upon the diagnostic signs which are said to be indicative of wounds of the intestines or other viscera, since I believe the diagnosis should be made by the eye alone, *i. e.*, the track of the ball should be carefully enlarged with full aseptic precautions until it is decided whether the peritoneum has been penetrated or not, and if a perforation be found, a median section should be immediately done to ascertain the existence of, and to repair any further damage. Although apparently heroic, this advice is really conservative, since all the rational symptoms of peritoneal penetration and visceral injury have proved fallacious, and if there be no peritoneal wound, what harm can result from the careful aseptic enlargement of the track of a ball wound involving only the abdominal walls? What I have just said is only strictly applicable when the wound of entrance or exit implicates the anterior or lateral portion of the abdomen, for when the ball penetrates its posterior wall, or has first passed through the thoracic or pelvic parietes, it will be inadmissible to determine the fact of peritoneal penetration by direct exploration of the wound or wounds, and the rational signs of penetration will have to be relied upon. Under these circumstances a correct opinion is always most difficult and oftentimes impossible without laparotomy.

I shall only dwell in the briefest manner upon the rational signs of peritoneal and visceral injury, since they will rarely be needed to determine the advisability of operation, and others, notably Bryant, of New York, have treated most admirably of this part of the subject. Of course, the escape of bile, faeces, urine or the contents of the stomach at once settles both the question of peritoneal and visceral penetration, but these signs are rare even after numerous visceral wounds produced by the small modern balls which commonly cause the gunshot injuries of civil life. Repeated vomiting of considerable quantities of blood almost certainly indicates peritoneal and visceral penetration, although this symptom may be due to contusion, and is unlikely to be present even with numerous wounds unless one involved the stomach, duode-

num or, perhaps, the jejunum high up; while, of course, in uncomplicated hepatic, pancreatic, renal, splenic, mesenteric, omental and vascular traumatisms, it is absent. The passage of blood in quantity per anum is also strong presumptive proof, but it so rarely occurs early in the case as to be of little practical diagnostic value for operative purposes.

The presence in the abdomen, within an hour or two of the injury, of a sufficient bulk of fluid to be detectable by physical exploration positively indicates peritoneal penetration, and probably visceral injury, since only intra-abdominal hemorrhage could produce such a rapid accumulation. Some such cases have, I believe, been reported. The rapid supervention of general peritoneal tympany, *i. e.*, an accumulation of intestinal gas in the general peritoneal cavity—is a certain sign of wound both of peritoneum and gut, but to be of any great value it must supervene within a very short time of the injury. So far as I can ascertain it has not yet been noted previous to abdominal sections for ball wounds. Finally, an amount of hemorrhage which can neither be accounted for nor arrested after a careful examination of the parietal wounds, almost certainly indicates penetration and vascular or visceral injury.

It will be noticed that I have omitted many symptoms usually given, but they have proved so utterly fallacious in many instances as to be unworthy of the name of diagnostic signs. Shock preeminently belongs to this category.

If we exclude those rare cases where there is only a wound of entrance in an unusual site, for instance, the posterior lumbar region, I feel that it is a far graver question to decide when not to operate than when to operate. I shall only tentatively point out the contraindications, for I consider that laparotomy for ball wounds is of too recent date for anything beyond provisional indications and contraindications.

Profound shock, provided it be not mainly due to a loss of blood which can probably be rapidly arrested after the abdomen is opened, is an undoubted contraindication. If the greater part of the shock be not due to haemorrhage, the prolonged handling of the bowels, especially in the young or old, is apt, through irritation of the abdominal sympathetic, to pro-

duce a dangerous amount of prostration in those whose vital powers have been already depressed by the injury. Such an effusion of blood escaping externally, internally, or in both directions, as would render it probable that the added shock of an operation would terminate life before, or in spite of the arrest of haemorrhage, contraindicates laparotomy. As I cannot conceive of any circumstances where at least a perfectly clean abdominal wall, hands and instruments are unattainable, with some germicide such as mercuric bichloride, iodoform, subiodide of bismuth, tincture of iodine or carbolic acid, with at least one tolerably competent assistant, the surroundings of a patient should never contraindicate operation in an appropriate case, provided the operator be experienced in abdominal surgery; for I cannot think that the average practitioner should attempt a laparotomy for gunshot wound. An operation demanding so much care, experience and attention to detail, can rarely be properly performed by a tyro, i. e. every traumatism discovered and repaired—without undue loss of time and unnecessary handling of the viscera. If possible, only one pair of hands should be introduced into the abdominal cavity, and those the operator's; so that I contend that inexperience approaches very closely to a positive contraindication.

When a skilled operator cannot be secured, in exceptionally favorable cases the attempt may be made and succeed, but most cases will do better left to nature than operated on by a bungling surgeon, who from the nervousness induced by inexperience will, in his hurry, overlook wounds or some of the essential details of aseptic abdominal surgery. In support of my statement, that experience is requisite for this operation, I would ask you to reflect, how much more difficult it is to open an abdomen with tense and rigid walls, take out, examine and replace twenty odd feet of intestines and critically inspect all the abdominal organs, than it is to remove a large ovarian tumor which leaves the parietes lax, thus giving abundance of space.

If, because the patient has been seen too late, a generalized, well-advanced peritonitis exists, laparotomy is strongly contra-

indicated, for, since the main aim of the operation is to *prevent* diffused, unhealthy peritonitis, no indication for its performance any longer exists. It is true that abdominal section has been advocated and successfully performed for acute peritonitis, but I do not think it will do aught but harm in cases following gunshot wounds of the abdomen with visceral injury; possibly where no visceral complications exist, it may prove occasionally useful. If it was possible to determine beforehand that only one perforation existed, a laparotomy might be done, and, provided the injured loop of bowel could be found and secured in the abdominal wound and free drainage instituted, good might accrue; but my experience of laparotomy after diffused peritonitis following rupture of the intestines and for ball-wounds, teaches me that it is extremely improbable that we should be able to find the wounded bowel without excessively prolonged manipulation; that the gut would be in no condition to suture; that multiple perforations would be so situated that all the loops of injured intestine could not be secured in the abdominal wound—and if all cannot be thus held so as to discharge their contents externally, what good can the operation do?—and finally that neither free drainage nor an effectual toilet of the peritoneum can be secured. Wounds of the solid viscera will, according to their ascertained or probable severity, serve as contraindications or the reverse.

With reference to the proper time for operation I can only say that both experience and experiment seem imperatively to demand that laparotomy should be done at the earliest possible moment the condition of the patient will warrant it. Shock—which is usually not well marked—is all that should withhold us, and not even this, if haemorrhage is producing the condition, in which case, as in other severe injuries, the operation must be at once proceeded with, despite the unfavorable condition of the patient, lack of proper assistance, preparations, etc.¹ It is only under such desperate circumstances—and they can but rarely obtain—that we are warranted in operating without having most scrupulously provided for every contingency;

¹ Shock arises in most instances of ball-injury, from severe haemorrhage, at least this is my opinion.

for it must be borne in mind that after opening the abdomen, serious haemorrhage may be found arising from the liver, kidney, pancreas or spleen, that resections of portions of intestine may be necessary, and I can readily conceive that before long we shall find reports where the splenic or a renal artery has been wounded demanding removal of the organ whose blood supply will be cut off by the ligature of its nutrient artery.¹ Present experience seems to demand the adoption of the following precautions. I shall first indicate what should be provided when obtainable, afterwards detailing what substitutes can be used in emergencies: First, all pubic or other hair must be shaved off, the skin of the abdomen, especially that of the umbilical depressions, thoroughly cleansed by the free application with a nail-brush, of turpentine 2 parts, alcohol 14 parts, which must then be thoroughly removed with the nail-brush, soap and warm water, and a cloth soaked in mercuric bichloride solution laid over the abdomen while the patient is being etherized; indeed, when circumstances will admit, all the cleansing had better be done before etherization. Washing the parts with ether, alcohol, antiseptic, or plain soap and water and the application of a cloth wet with carbolic acid solution, thymol, salicylic or boracic acid solutions, or a very weak iodine tincture solution, will do in an emergency. Abundance of freshly distilled recently boiled water should be at hand, some kept hot, some cold, with a large fountain syringe for flushing the abdominal cavity. This water can be usually readily obtained from the condensed steam collectable from the steam-heating apparatus of most hospitals, needing nothing but filtration and boiling to insure its sterility. If this is not obtainable, one part of mercuric bichloride to ten thousand of water, one part of carbolic acid to five hundred of water, or larger proportions of water, may be used, the water boiled, allowed to settle and decanted for use. I look upon the addition of these germicides simply as insur-

¹ Some two weeks after penning these lines, I was informed that one of our fellows, Dr. W. W. Keen, had been compelled to remove the left kidney on account of the uncontrollable haemorrhage following a ball-wound.

ing the sterility of the water, not that they are to kill germs already present in the abdomen, or which gain access to it during the operation; none of these should be allowed to enter, and any that do, must be mechanically removed by a proper toilet, and above all by the free flushing of the cavity with this sterilized water. Used thus I believe germicides do good, but in anything like full strength, I look upon them as only harmful.

In like manner, the sponges, towels and instruments should be first carefully cleansed with soap and water—to which carbolic acid may be added, if desired—and then placed in the hot sterilized water. Special attention should be paid to the cleansing of the handles of instruments, which if roughened must be thoroughly scrubbed with the nail-brush. The operator's and assistant's hands and finger nails should be most scrupulously cleansed with the nail-brush, etc., and the sterilized water, or an antiseptic solution. Six aseptic sponges should be provided, three of which should be on handles or held by sponge-holders. When soiled, they should be first cleansed in one vessel, and then rinsed out in fresh water before being used again. A number of soft old linen or flannel cloths should be handy, lying in the hot sterilized water, to envelope the intestines in. I would suggest that as few instruments as possible be used, viz., one scalpel, a probe-pointed knife, a director, one tenaculum, one aneurism needle, two fine sewing needles threaded with fine pure silk, another coarser, and threaded with dry aseptic gut, two ordinary surgical needles threaded with heavy silk, half a dozen haemostatic forceps, a thermo-cautery, one pair of scissors, and abundance of silk and catgut ligatures, all kept beneath the sterilized water, or in a carbolized solution, according to the surgeon's preference. Whenever the instruments or sponges are not in use, they should either be rinsed off and then placed in the sterilized water, or laid upon a clean towel wrung out in the same. Every instrument, needle, sponge and cloth, must be counted *before* and *after* the operation. A small quantity of either iodoform gauze, or plain gauze with its meshes filled with the powder of this drug must be at hand to tampon a wounded liver, spleen or kidney.

As a dressing, my personal preference is the free application of iodoform to the line of the wound, and dry absorbent cotton with a snug flannel binder; but corrosive gauze, sub-iodide of bismuth, carbolized gauze, eucalyptol, etc., with broad rubber adhesive straps should be provided, according to each one's liking or custom, with such additional instruments as may be deemed necessary. If drainage be used, a glass-tube is the most desirable form to employ, but if not obtainable, a large *non-perforated* rubber one can be substituted. A hypodermic syringe, with solution of atropia, whiskey, hot water-bags, bottles or bricks, must also be ready for instant use.

Now as to technique. The patient's limbs and trunk must be carefully wrapped in blankets, with towels wrung out of the aseptic or antiseptic solution, tucked under and folded over them around the abdomen to prevent any accidental contamination of the peritoneal cavity. If not previously done, the urine should now be drawn off, lest from a bladder wound the fluid become forced throughout the abdominal cavity by the patient's struggles. Ether should be most cautiously administered.

The incision should always be median, as otherwise it is almost impossible to gain a proper view of the parts,¹ and should usually extend from a short distance above the umbilicus to about two inches above the pubes. The abdomen having been opened, any clots or blood which obscure the operating field may be removed, but otherwise, unless it is manifest that severe haemorrhage is going on, the small intestines, which usually first present, should be carefully gone over, inch by inch, from the stomach to the ileo-cœcal valve, keeping them constantly enveloped in towels wrung out of hot water; afterwards the stomach, spleen, liver, pancreas, large bowel, kidneys, bladder, omentum, mesentery, and abdominal vessels must be examined. I do not mean that if various wounds are discovered—say in the small intestine—and the place of exit of the ball

¹Neglect of this rule has proved disastrous in more than one instance.

See Dr. J. H. Packard's case, Med. News, March 26, 1887, pp. 339 to 341, where after the toilet had been commenced free bleeding was discovered necessitating a search deep in the pelvis to find a wounded iliac vein.

from the abdominal cavity, all in such relations as would absolutely exclude injury of the stomach, liver, kidneys, spleen or bladder, that such a detailed examination should be made—far from it—for every unnecessary manipulation is injurious; but I do advise that, rather than overlook a wound, much manipulation which the result proves to have been unnecessary, had better be made. Of course, the source of a severe haemorrhage must be at once sought for, and any wounds of the hollow viscera ignored for the time being, care however being taken that the general peritoneal cavity is protected from faecal extravasation by removing the intestines outside the abdomen, keeping them wrapped in warm, moist cloths: such haemorrhage is, however most unusual. Whatever plan is pursued, let everything be done methodically, and each injury repaired as it is detected, as this saves much time, and renders any oversight almost impossible. All wounds of the bowel, however trivial, should be minutely cleansed, coaptated by the Lembert suture of fine silk introduced with an ordinary sewing needle¹ and the suture-line rubbed over with a little iodoform.² When necessary from the size or number of the wounds a portion or the whole calibre of the gut must be excised.

Wounds of the liver, if situated at the free border of the organ, should if possible be coaptated with dry aseptic gut which will soon swell and fill the track made by the needles. If this cannot be done, the haemorrhage may perhaps be arrested by the judicious use of the thermo-cautery, but if the bleeding be free, the wound should be plugged with an iodoform gauze tampon which is to remain permanently, or may perhaps be carefully removed at the close of the operation, when, if the bleeding be almost entirely checked, the cautery may then be used as a

¹This is to secure as small a wounded surface of peritoneum as possible since the needle-track will be filled by the thread; the importance of this is clear by the light of the experiments quoted. In addition, Dr. J. H. Packard calls attention to the troublesome bleeding resulting from wounds of small vessels by the ordinary suture needle.

²Dr. W. T. Bull, the most successful operator for ball-injuries has always used this method of dressing.

Recommended by Senn, of Milwaukee, I believe.

further precaution—if the flow be free, the tampon must be replaced and allowed to remain permanently.

Wounds of the pancreas, spleen, or kidneys, must be treated in a similar manner, or if these measures fail, either spleen or kidney must be excised. Since a wounded splenic artery would inevitably result in gangrene of the organ, it must be removed. The same advice holds good for wound of a renal artery, but in these cases death from haemorrhage will usually result before art can intervene; still, such possible complications must be provided for. Wounds of the bladder had better be sewed with dry chromic and sulphurous acid gut which by its swelling will fill the track of the little wounds, and the needle used should be a round one, as small as can be made to carry the thread. Contused bowel will almost certainly slough, so that the injured portion had better be excised and the healthy peritoneal surfaces united by suture.¹ Wounded or contused omentum or mesentery must also be excised, and the edges carefully united by interrupted sutures. The experience of at least one case has shown, that since an omental slough cannot be eliminated into the lumen of the bowel as occurs in wounds of the intestine, a fatal generalized peritonitis will result from the local gangrene of the injured part. All bleeding must be checked even from the smallest vessels, for quite extensive oozing will occur from most insignificant vascular orifices because they are situated in a closed cavity, and although the amount lost may not be dangerous *per se*, it will prove so as a source of septicaemia or peritonitis.

If a segment of bowel is to be excised, the cuts should be made at such points as correspond to the distribution of a large mesenteric branch, in order to secure a due blood-supply to the edges of the incisions, and the parts to be removed should be laid upon a large, flat sponge, or folded napkins to prevent faecal extravasation into the abdominal cavity. To obviate kinking of the bowel, a V-shaped piece of the mesentery must

¹ Parkes contends that the peritoneum can be safely united over the contused spot with a continuous catgut suture, except where the injury involves the mesenteric attachment, when it must be excised.

be removed, the branches of the V not corresponding to the cut edges of the bowel, but presenting a free margin of an eighth of an inch lest want of vascularity cause failure of union at this, the most doubtful point. After arresting haemorrhage, the mesenteric wound must be carefully coaptated by numerous points of interrupted suture. Now the bowel should be united by the Lembert suture, turning in at least one-fourth of an inch of the serous coat, or by the Czerny-Lembert, Gussenbauer or other suture, whichever is preferred, although the Lembert, with sufficient inversion of serous coat, is thoroughly reliable.

The first stitches must be placed at the mesenteric border, are the hardest to make efficient, and should be three in number to secure perfect contact of the serous surfaces, as Parkes observes. One stitch directly opposite the mesentery, and a third and fourth equidistant between the first two should then be passed, after which the intermediate ones can be inserted about one-eighth of an inch apart, first carefully inverting the mucous membrane. For special details and numerous ingenious devices I must refer you to the admirable experimental paper of Parkes and the writings of Treves, Ashhurst and others.

Should the pulse fail at any time during the operation, owing to irritation and paresis of the abdominal sympathetic, flushing the intestines and peritoneal cavity with hot water will oftentimes at once remove the unfavorable condition. The most scrupulous care must be exercised in the peritoneal toilet, which can be most quickly and effectively made by thorough irrigation of the cavity with warm sterilized water¹ and subsequent careful removal of all fluid in the ordinary manner by sponges, especial attention being paid to the cavity of the pelvis, and the renal regions.

When possible, the peritoneum should be carefully united over the orifices of entrance and exit of the ball, just as in the case of intestinal wounds, and a little iodoform rubbed in.²

¹Sterilized either by being distilled and boiled, or by adding minute quantities of some antiseptic.

²If the puncture made by the hypodermic needle in experimentation was the starting point of a peritonitis, much more will the wounds be made by a ball. I think this matter has been too completely ignored.

Closure of the abdominal wound should be effected by first carefully suturing the peritoneum with fine silk or catgut. This I look upon as most important, since the tenseness of the abdominal walls, so different from the conditions existing after the removal of a tumor, render it extremely difficult to bring the peritoneal surfaces into proper apposition without undue traction on the sutures, thus possibly leaving raw surfaces which may serve as the starting-point of a peritonitis, while, even if not provocative of such serious consequences, a ventral hernia will almost certainly result.

The muscular, aponeurotic and cutaneous structures should then be carefully coaptated by stout silk sutures, iodoform be freely dusted along the wound, which may be supported by one or more broad rubber adhesive strips, if thought desirable, when a thick layer of absorbent cotton and a flannel binder will complete the dressing. The patient should now be placed in his previously heated bed, with limbs flexed over a pillow,¹ the urine drawn, external warmth applied, and stimulants, such as atropia or whiskey given hypodermically, if they are indicated. If not, a moderate hypodermic of morphia must be administered combined with a small dose of atropia and rest enforced.²

When incipient peritonitis exists at the time of operation, with the probable formation of large quantities of acrid, septicæmic or sapræmic inducing serum, drainage should in all cases be instituted, for some patients have, I think, perished for want of this precaution.³ The tube, preferably of glass, should have its end kept well down between the rectum and bladder in the male, or in Douglass' cul-de-sac in the female, with the external orifice plugged with iodoform cotton.

The after treatment will be considered under three different heads, viz. :—

I. When peritonitis does not exist at the time of operation, in other words, when a primary operation has been performed.

¹ When purulent peritonitis exists, a lateral decubitus is perhaps advisable.

² I can conceive of cases where transfusion, or the temporary use of Esmarch's bandages to the limbs might be indicated, where death is imminent from severe haemorrhage.

³ Some of Parkes' experiments exemplify this point.

2. When incipient peritonitis does exist at the time of operation, *i. e.*, when a secondary operation has been done; and—
3. When, despite all our efforts, or due to some *négligé* in technique, peritonitis develops after operation.

1. Under the first conditions, a recumbent position, with flexed knees, seldom changed—and then not by the patient's efforts—should be insisted upon. Alimentation must be carried on by the rectum entirely, when possible, for at least forty-eight hours, and in some cases even longer, when the stomach is irritable. At the most, cracked ice and small quantities of beef peptonoids should be given when the rectum rejects enemata, or when feeding by the mouth is begun. The higher up the intestinal canal the wounds are, the more imperative the rectal feeding becomes. At the end of a few days, larger quantities of food may be given. Should tympany occur to any extent, the rectal tube and the enemata should be tried. If masses of *faeces* are present, or suspected to be lodged in the colon, about thirty to sixty grains of inspissated ox-gall dissolved in some mucilaginous vehicle should form the enema, and will sometimes relieve severe tympanites where an ordinary injection will fail, owing to occlusion of the gut by *faecal* plugging.

2. When a pre-existent incipient peritonitis has necessitated drainage, the tube should be periodically emptied by a syringe with a soft-rubber tube attached, the syringe kept aseptic, and tube corked with iodoform cotton. Should the discharge become large or purulent, one careful irrigation with weak mercuric bichloride solution, followed up with boracic or salicylic acid solution, should be resorted to. With a large amount of discharge, a lateral or semi-prone position, which will favor drainage, is advisable when the patient can assume either attitude.

Neither much food nor alcoholic stimulants will be needed even in this condition, since either the patient will die before true exhaustion demanding large quantities of aliment and alcohol comes on, or recovery will ensue. As will presently

be explained, atropia is better than alcohol for the shock of commencing peritonitis, or the "exhaustion" of the latter stages, *i. e.*, the depression of the nerve centres, especially those of circulation and respiration.

3. When peritonitis develops after the operation, our initial treatment must depend on whether the disease comes on gradually or suddenly. When the latter occurs, there is at times decided evidence of shock from vasomotor paresis, evidenced by an apathetic semi-conscious condition, with extended limbs, pinched features, and a weak pulse—in such a condition opium in large doses will probably prove fatal, while *small* doses of morphia with atropia will relieve pain and stimulate the heart. The heart itself always should be examined by auscultation, since this may demonstrate that its action is really feeble, while the pulse feels hard and wiry. Now, under such circumstances the pain is often severe, but large doses of opium, unless combined with atropia or digitalis, are very dangerous. I say large doses, meaning by this term those ordinarily recommended for peritonitis in the textbooks.

Later on, owing to asthenia, the recumbent position, and the compression of the lungs by tympanites, hypostatic pneumonia is apt to develop, when the improperly aerated blood tends to paralyze the respiratory centres. Here morphia must be very cautiously given, or better, in many cases withheld, and when given at all must be guarded by ammonia, atropia or digitalis. Stimulating hypodermic injections and revulsives, such as dry cups to the chest, are indicated. Where peritonitis develops gradually, opium can be given more freely, remembering that the ideal condition to be obtained by opium is freedom from pain, irrespective of the quantity of opium exhibited; and when this is secured a patient falls asleep, *but can be readily aroused*.¹

This last sentence is the keynote of the opium treatment. Morphia had better be the drug employed, and should be given hypodermically, since opium by the mouth is not always absorbed, and may lie unchanged in the stomach or intestines

¹Burchard, New York Medical Journal, August 15, 1885, op. cit.

for days to be suddenly taken up in fatal quantity. "In the later stages of peritonitis, especially when the heart and lungs fail, and when gastric regurgitations and hiccup are rapidly exhausting the patient's vitality, one or more hypodermics of atropia, varying in strength from one-sixtieth to one-tenth of a grain each, either alone or in combination with morphine, digitaline, ammonia or alcohol," according to indication, will at times save an otherwise hopeless case.

In addition, we undoubtedly possess two powerful means of directly affecting the vascular processes involved in a peritonitis. Free leeching done at the commencement of the attack, or when it has not progressed far, is of signal benefit, provided the patient has not lost much blood from the accident. This I have witnessed at the bedside of patients, and also experimentally proved, as may be gathered from my observations on blood-letting read before this Association three years ago. Cold, by means of the ice-coil to the abdomen, is a second means of controlling peritonitis. Cold applied to a peripheral sensory nerve has been shown by physiological experiment to control the afflux of blood to those parts supplied by the vaso-motor nerves which inosculate with such sensory branches. In the present instance, the nervous circuit consists of the lumbar nerves, supplying sensory filaments to the abdominal parietes, and the branches of the solar plexus which are distributed to the intestines and peritoneum. Cold applied to the former nerves, *i. e.*, to the abdominal wall, will therefore cause contraction of the blood-vessels of the peritoneum and intestines. It will do more; for it lowers the temperature, relieves tympany and calms the nervous system.¹

Should the sutures uniting a resected or wounded bowel have given way, nothing remains but reopening the wound, irrigating the cavity with an antiseptic solution, and the attempt to secure the bowel in the abdominal wound—in other words, form an artificial anus; but practically this question will hardly arise.

¹Leiter's block-tin coil is, of course, the best means for applying cold, but a few yards of half-inch rubber tubing kept coiled up by means of three equi-distant narrow strips of tin so interwoven with the tubing as to keep the coil flat, will prove nearly as effectual and can always be obtained in an emergency.

Should persistent and rising temperature, despite the ice-coil etc., be present without the local signs of peritonitis,¹ I should suspect the presence of some fluids which, generating ptomaines, were being absorbed and producing sapræmia. In such an event, the reopening of one angle of the wound, free irrigation of the abdominal cavity with safe antiseptic fluids, and the retention of a drainage tube managed as I have already directed, would perhaps save some otherwise condemned patients. In the same way, should septic peritonitis arise, with probable effusion of large quantities of fluid, such as are often found after death, I should strongly advocate a similar plan of treatment. Owing to the anatomical position of the kidneys, they are liable to become involved when the peritoneum is inflamed: hence, the use of turpentine is to be deprecated. Burchard states that "more than once has the timely application of cups and a digitalis poultice over the kidneys saved" for him, "the life of a patient who was insidiously developing a nephritis." Daily examinations of the urine should therefore be made, since retention of the urinary excreta in nephritis is a well known cause of peritonitis. Digitalis in some forms, and perhaps other diuretics, are also peculiarly indicated in the sapræmic condition, to aid in the evacuation of the poisonous ptomaines, for if none of these products are allowed to remain in the abdominal cavity, and those already absorbed can be eliminated, recovery will often ensue. I can hardly conceive as I have already said, of a case of this variety of traumatic peritonitis living sufficiently long to develop enough true exhaustion to demand large quantities of food and stimulants; but should this occur, of course the experiment must be tried, although the stomach will probably rebel.

In conclusion I wish to repeat that everything advanced must be viewed as more or less provisional, since sufficient experience of the operative treatment of these cases has not yet accumulated to warrant positive statements.

¹ Provided no symptoms of shock were present such as I have already described as ushering in a sudden attack of peritonitis.